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JOINT SEALING PRACTICE FOR LONGER SPANS

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Committee on Bridges & Structures of the

American Association of State Highway Officials

INTRODUCTION

A foreseeable trend to longer span bridges together with the realization that there is a definite, causal relationship between certain identifiable types of premature bridge distress and ineffective sealing practices has led to the recent development and use of a number of interesting new sealing systems across the free world utilizing the compression principle.

Recent comprehensive field tests in a number of countries, provinces and state highway departments have given an indication that in the light of present knowledge, we must face up to the hard fact that the poured-in-place mastics, thermoplastics and exotic field molded sealants do not have a sufficient performance capability for even our shortest spans. They may in fact have no place at all on a bridge regardless of length. The bridge sealing problem is in its simplest form a complex one and is further complicated by the fact that each structure is unique in itself so that no two structures have exactly the same performance need. Recently, responsible producers of field molded sealants have issued definitive literature restricting the use of these materials to only the very shortest of spans and for all practical purposes have eliminated their usage on bridges.

Since few bridge designers would agree to the feasability of standardizing the design of all bridges for reasons of economy, environment, aesthetics and a multiplicity of regional or local factors, then we must recognize that insofar as the sealing problem is concerned, each bridge joint must be considered separately and its performance need rated according to the design of each structure.

In the past, much of our bridge construction consisted of spans of short length such as 50 ft and down whereas today, bridge design engineers are stretching out the lengths of many of their bridges to longer spans as design and construction techniques have been improved. It is difficult then to find a common description of the difference between a short and long span other than a short-span bridge is one in which the live load governs the design, whereas a long-span bridge is one in which the dead load governs.

Since the joint sealing problem is primarily concerned with arriving at a series of solutions to accomodate a wide spectrum of movement phenomena, for the purpose of this discussion, we will consider that a long-span bridge is one in which the longitudinal distance change between the deck slab ends, from pole to pole of movement, will exceed one inch.

DESCRIPTION OF THE PROBLEM

While it could appear to be elementary for a group of practicing engineers to review the categories of typical premature bridge distress, it may be well to have agreement on, or an understanding of, the problem if we are to expect any agreement on a given solution.

It is anticipated that much of the expensive maintenance cost of premature bridge distress related to ineffective joint sealing could be eliminated or certainly minimized if joints could only be sealed with some permanency. While the accompanying photographs show typical maintenance problems on bridges, it is recognized that environmental differences will place emphasis on certain types of distress being a serious problem in one geographic area while not being a cause for concern in another. Typical of this would be the salt brine deterioration of pier caps. Caution is to be observed however in generalizing that relatively balmy or mild climates would minimize the salt brine deterioration problem as compared to far northern environments inasmuch as there now exists relatively new documentation which attests that this deterioration can be more severe in areas where there are more cycles of freeze-thaw. It may be that the salt brine deterioration of pier cap problems could be more severe in Virginia, Kentucky, Kansas, Missouri and similar latitudes than it is in Connecticut, New York, Michigan, Minnesota and Canada. To generalize, bridge joint distress may be considered to differ in type from one environment to another, rather than in severity.

EXAMPLES OF TYPICAL PREMATURE BRIDGE DISTRESS CAUSALLY RELATED TO THE SEALING PROBLEM

In an attempt to better understand the cause and effect relationship between ineffective sealing practices and their effect on bridges and structures, a comprehensive photographic study of bridges was undertaken in the United States, Canada and a number of free world countries which has given evidence that certain common categories of premature distress are widespread throughout the world.

The accompanying photographs are an attempt to categorize the types of premature distress that can occur when the performance capability of a sealant is exceeded. (See Figures 1-38).

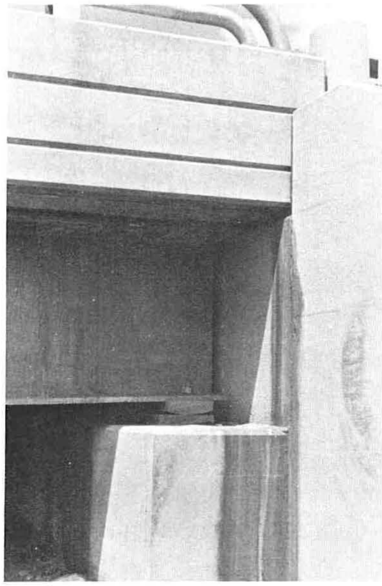

Figure 1. Aesthetics problem, staining, discoloration.

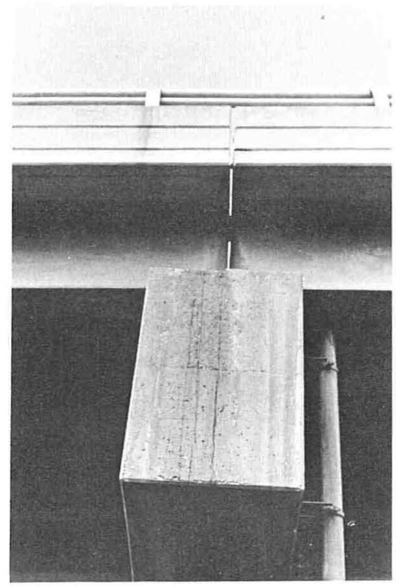

Figure 2. Aesthetics problem, staining, discoloration.

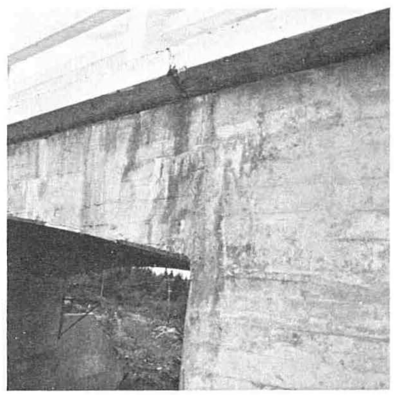

Figure 3. Aesthetics problem, staining, discoloration.

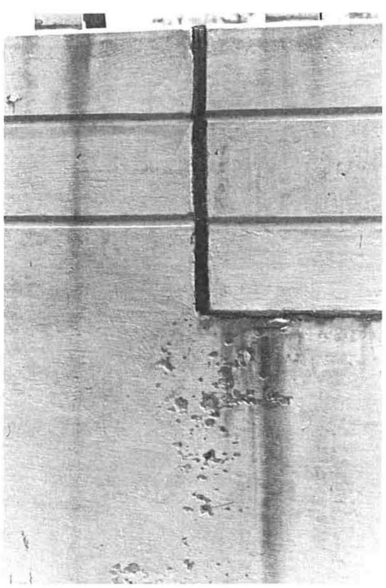

Figure 4. Aesthetics problem, staining, discoloration and the beginning loss of durability.

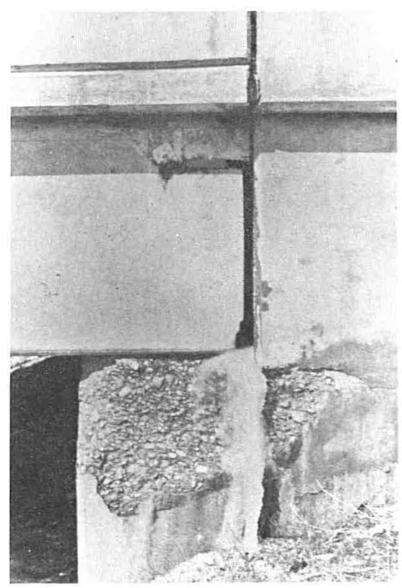

Figure 5. Typical salt brine deterioration of a bearing shelf with ice stalagmite illustrating hydraulics of freeze-thaw.

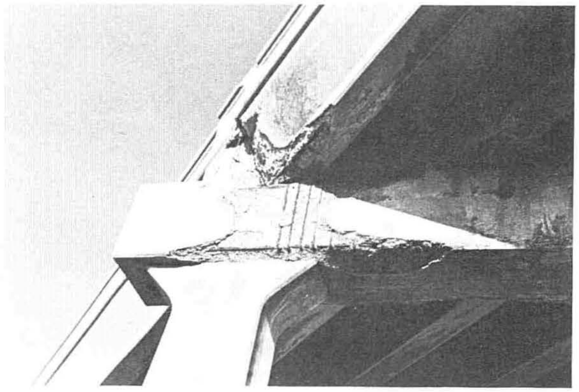

Figure 6. Typical salt brine deterioration of pier cap or bent with advanced corrosion of reinforcing bars. Products of corrosion require 5-10 times as much space as original steel cross section with resultant pop out.

Figure 7. Salt brine corrosion. Vibrations from traffic loading later on caused this pier cap to break off.

Figure 8. Salt brine corrosion. Structure is in excellent condition except under the joint area.

Figure 9. Corrosion of end of girder as well as bent.

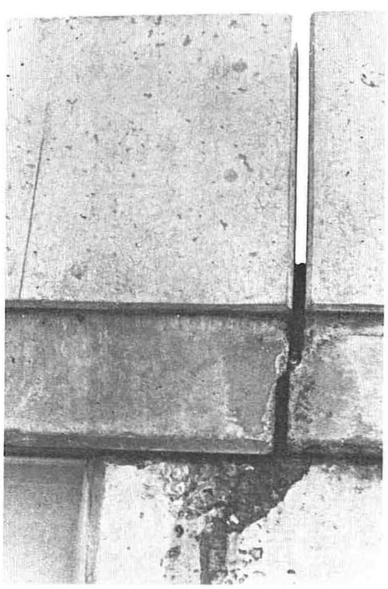

Figure 10. Beginning corrosion of bearing area.

Figure 11. Corrosion usually originates under the sidewalk and bridge rail, then progresses along the bent. Windrows of salt-laden snow on sidewalk together with decks sloped towards curb seem to result in a concentration of brine in this area of a bridge.

Figure 12. Corrosive attack from chemicals other than salt.

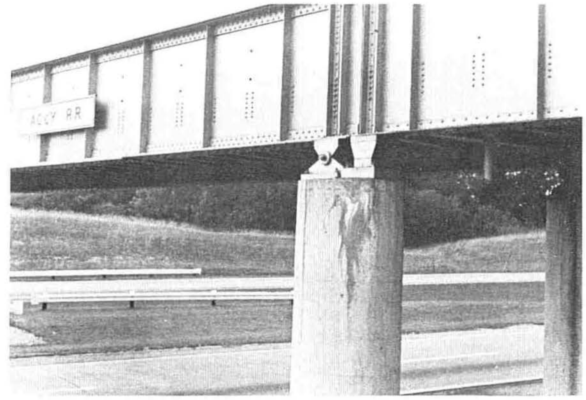

Figure 13. Corrosive attack on a railroad structure from chemicals other than salt.

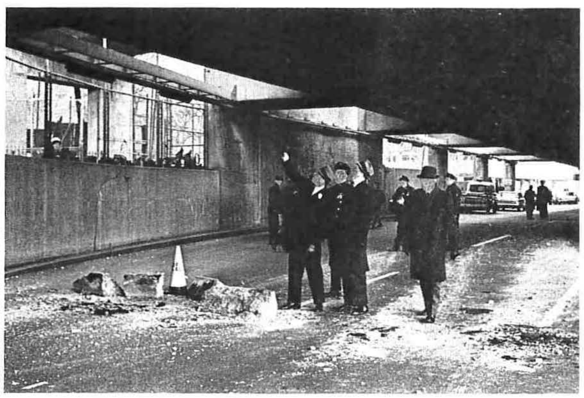

Figure 14. Erosion attributed to salt brine and vibration from traffic loading.

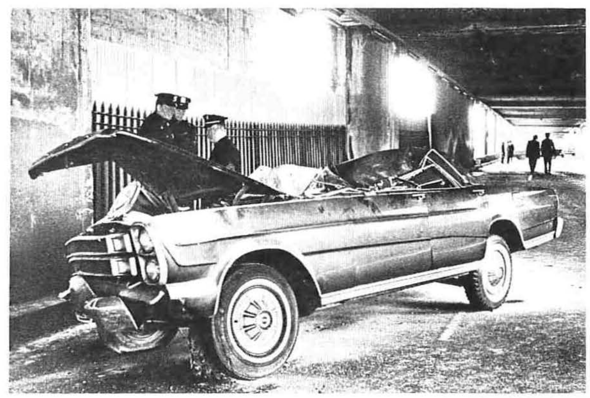

Figure 15. Erosion with resulting traffic hazard attributed to concentrated attack of brine at the joints.

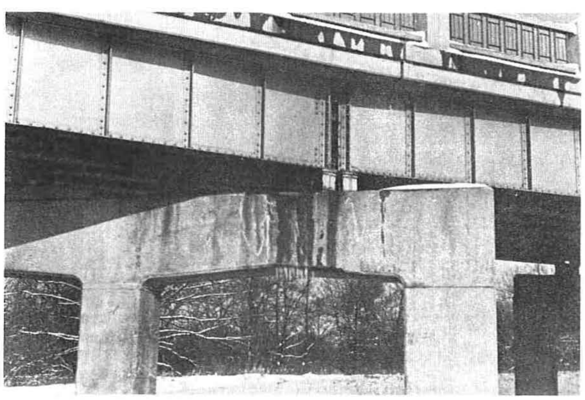

Figure 16. Beginnings of steel corrosion at the joints.

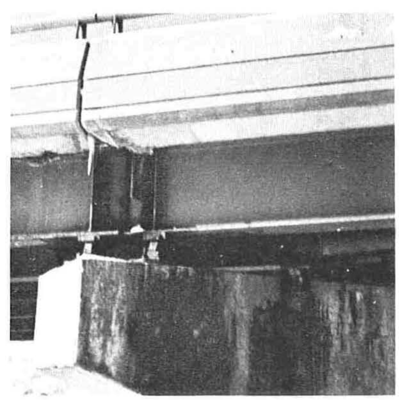

Figure 17. Corrosion of steel beam ends and bearings. Balance of structure is unaffected.

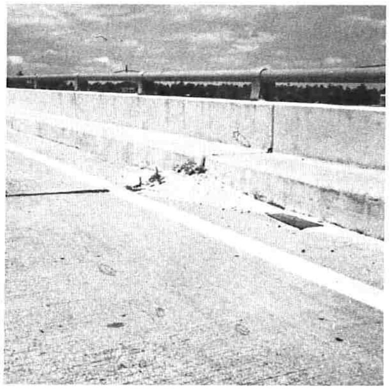

Figure 18. Accumulation of salt saturated debris, paper, leaves, rags, weed, soil, laitance.

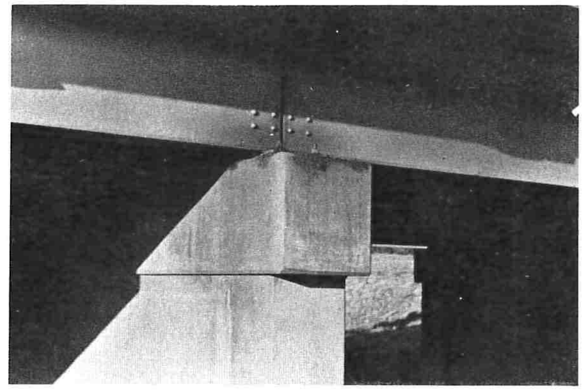

Figure 19. Salt saturated "poultice" on a new bent usually moisture laden.

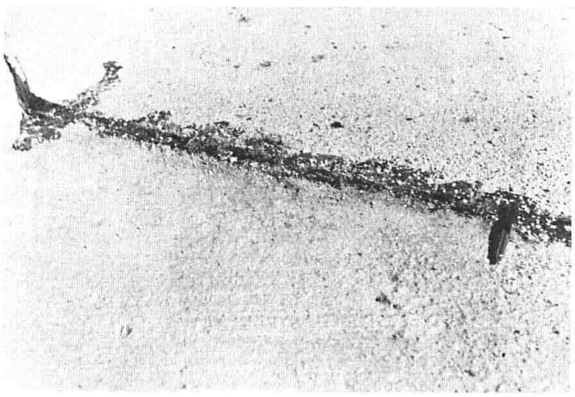

Figure 20. Root structure acts as a stop and serves as a restraint producing mechanism.

Figure 21. Concentrations of stress at the curb line.

Figure 22. Stress concentration due to vegetation growth is more of a problem in non-snow plow areas where growing season is long and climate favors growth. Snow plows tend to tear out heavy growth in snow belts.

Figure 23. Crushing due to intrusion of high friction material.

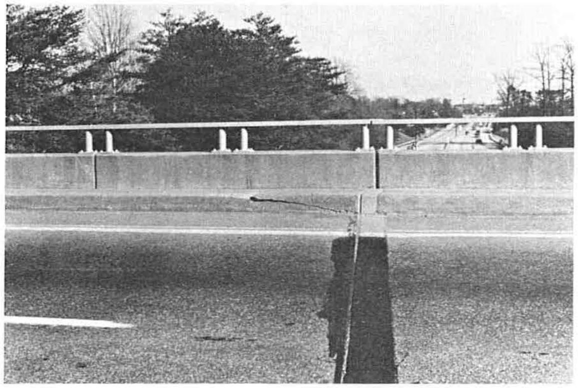

Figure 24. Sand defies extrusion and the weakest material in compression is susceptible to rupture.

Figure 25. A continuous span with a sliding plate joint is susceptible to crushing and stress concentrations at the curb line.

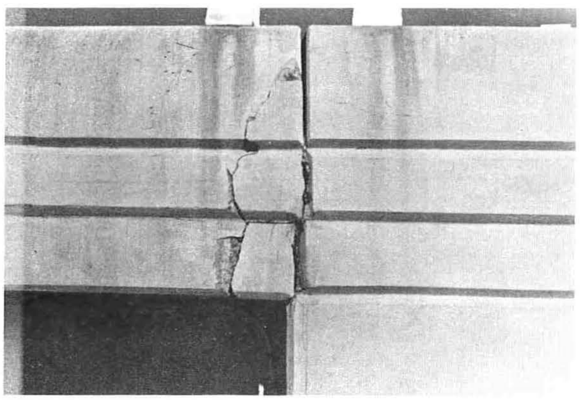

Figure 26. Deep intrusion of hard, stress-producing, high friction materials.

Figure 27. Evidence of stress relief attributable to pressure buildup from entry of foreign materials at mid-point of a bent.

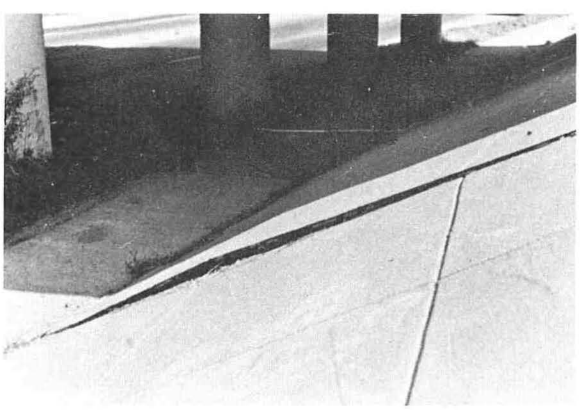

Figure 28. Backslope shifting in non-freeze climate.

Figure 29. Erosion of support on block-type back-slope.

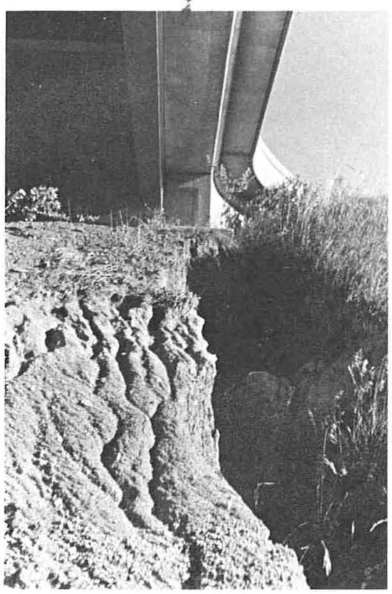

Figure 30. Washout of earthen backslope.

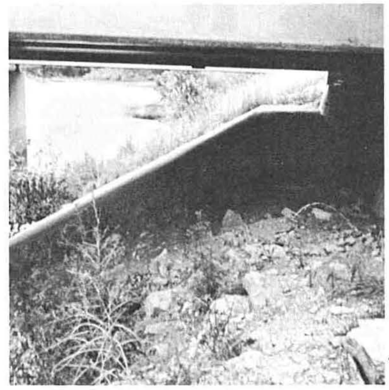

Figure 31. Half of a paved backslope under a continuous span carried into the river below. Heavy rains produce flood volumes of water under the few joints on a continuous span.

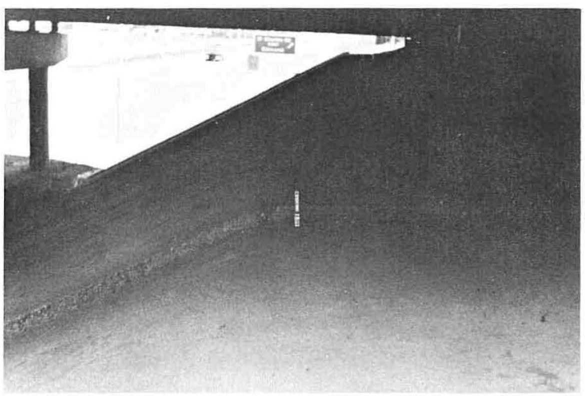

Figure 32. Shifting backslopes result in loss of support to backwall and can encourage backwall splitting.

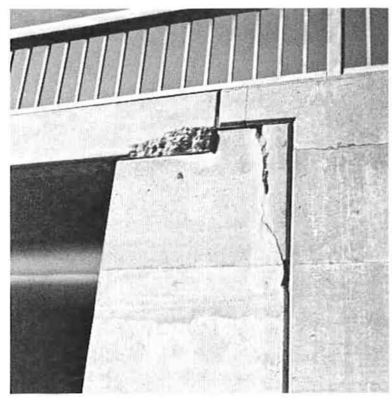

Figure 33. Pressure generation from intrusion of foreign material. Split backwalls are the combined result of lack of relief in both bridge joint and adjacent pavement joints.

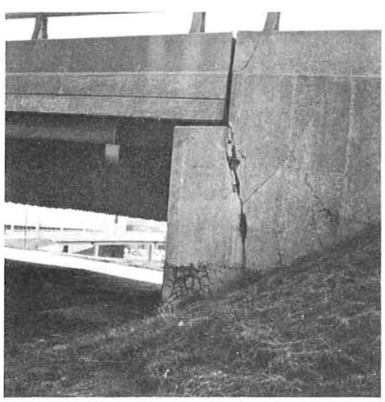

Figure 34. Pressure generation from intrusion of foreign materials. Loss of backwall support contributes to premature splitting. Continuous spans can be more susceptible to this category of distress.

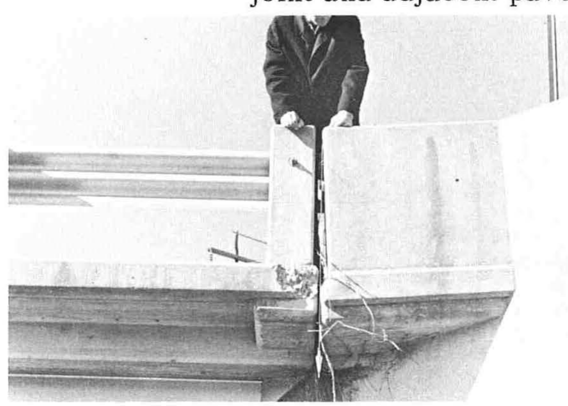

Figure 35. Pressure generation. Wingwall is rotated 10 degrees to the left of center. On very warm days, wingwall rotates as much as 15 degrees.

Figure 36. Pressure generation on a skewed joint. Bridge is forced out of longitudinal axis alignment.

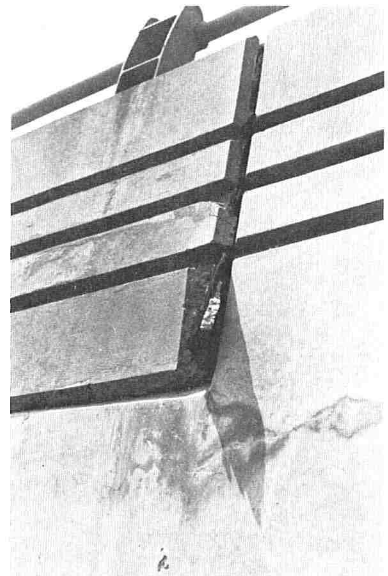

Figure 37. Pressure generation on a skewed joint. Joint filler material serves as a lubricant to facilitate sliding movement.

Figure 38. Pressure generation on a skewed joint. An older structure has been forced 12 inches out of alignment.

Watson, Stewart C. Can we satisfy every requirement below?

PERFORMANCE CRITERIA FOR A SEALING
SYSTEM ON LONGER SPANS

In light of the aforementioned typical bridge distress, it is considered that an effective joint sealing system must be equivalent to the following performance criteria:

1. It must have the capability to successfully respond to the many different types of movement that might occur on a specific bridge, whether it be straight distance change between the joint interfaces, racking distortion from the many variations of skews, horizontal, angular, vertical and articulating motion patterns, differential vibrations of slab ends, impact, warping and rotation effects, permanent changes in deck length, creep, plastic flow, etc.

Only in complex structures all of these movements are of concern.

2. It must have the capability to respond to the individual magnitudes of the above categories of movements both singularly and when acting in concert.

3. It must seal out the entry of incompressibles, compressibles and in fact, all types of foreign material with a restraint producing potential and guarantee that bearing seats, shelves, pier caps, bents, do not receive accumulations of these materials together with chemicals deleterious to steel and concrete's performance life.

4. It must seal out the entry of free water in a leak proof manner and assist in channelizing the water into the drainage system of the structure.

5. It must be capable of absorbing the various types and ranges of movement within itself without being extruded above or expelled from the joint opening.

6. With respect to the riding surface of the sealing system, it must be constructed of materials which have a capability to withstand wear and impact such as is produced from forces of repetitive and heavy traffic loadings coupled with ice, snow, slush, maintenance materials and incompressibles, the forces of abrasion from snow plow blades at low temperatures, abrasive effects of sand, silt, small stones, gravel, grit, laitance, etc. (See Figure 39 for typical attrition of an elastomeric riding surface).

7. It must be capable of performance in extremes of temperatures for the environments of each particular structure. (Bridges in Alaska encounter minus 70 degrees F while bridges in Southwestern United States can build up deck temperatures of plus 150 degrees F).

8. The sealing system must be constructed of materials that have a long outdoor service capability. All materials utilized must be relatively unaffected by sunlight, ozone, petroleum products, chlorides, deleterious chemicals from industrial smog, maintenance chemicals, cement alkalis, as well as tensile and compressive stress of long term duration.

not very important

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9. The surface of the sealing system should have provision for skid resistance if the device is of a longitudinal width greater than 8 inches.

10. The sealing system should be easily capable of inspection and maintenance and have provision for adjustments to take into account one-time or permanent changes in the bridge deck length (positive or negative creep) as well as movements from pavement pressures, settling of abutments or other similar forces commonly brought to bear against decks and abutments.

not in one exclusive way - see our report.

11. The sealing system should allow relatively unrestricted movement of the bridge to relieve stresses due to temperature, creep, shrinkage and loading unless the bridge is designed to accept these categories of stress. Should a device produce excessive stress, it could be capable of ejecting a bridge from its bearing points or produce other undesirable forms of stress relief.

again these are limits!

12. It should have a service life at least equal to the life of the deck surfacing and ideally to the life of the bridge. Short lived sealing solutions should have provision for simple and easy replacement with minimal cost.

13. The sealing system should have good riding qualities and generate neither noise nor vibration due to traffic.

14. Wherein the joint opening exceeds 4 inches at the widest point of opening, the sealing system should provide adequate structural support for traffic loadings that are not subject to rapid attrition or wear.

15. The sealing system must be equally effective at the juncture of the pavement and curb, this being the critical area for sealing of the bridge.

16. The sealing system should be free of breaks or field joints within the line of a given joint. Where sections of elastomeric tubes are fabricated in pieces shorter than the actual length required, they should be factory vulcanized. (See Figure 40).

This problem needs further study

DETERMINATION OF THE TYPE AND MAGNITUDE OF MOVEMENTS

With respect to solving the joint sealing problem, bridge design engineers must be able to make the following judgments:

1. Identify and describe the different types of important movement phenomena that will occur.

2. Predict with reliability the magnitude of each type of movement.

3. Insofar as progressively closing or opening joints are concerned, predict when this phenomenon will occur in the life of the structure. ?

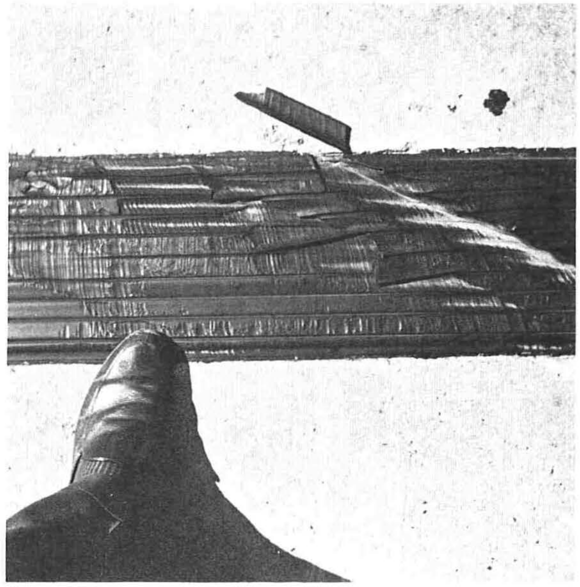

Figure 39. Typical attrition of an elastomeric surface under traffic, snow plows, stones, gravel, grit, laitance.

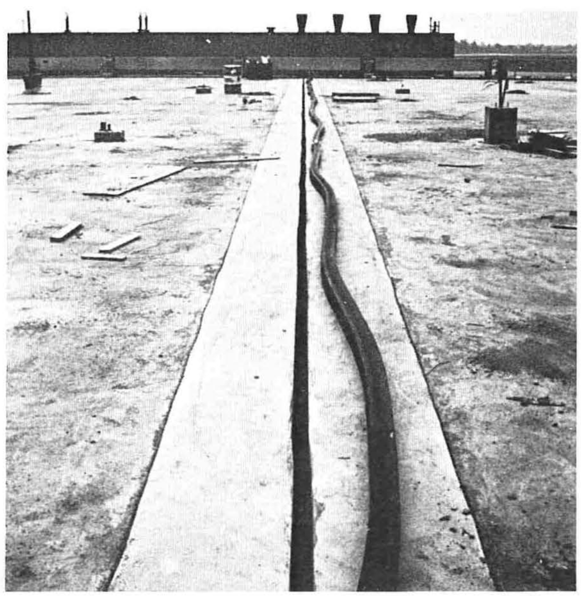

Figure 40. Typical compression seal 180 feet long weighing approximately 1000 lbs free of any field fabricated joints.

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SOURCES AND CATEGORIES OF MOVEMENT ON BRIDGES

Typical sources or categories of joint movement that occur on bridges and structures are listed hereafter:

1. Straight thermal movement (longitudinal distance change between adjacent slab ends or joint interfaces). The current AASHO Guide Spec suggests that we design in terms of 1/8" of movement for each 10 feet of deck or span length in a temperature gap of 100 degrees. Too simplified

2. Racking movements of skewed joints. (This phenomenon obviously differs in complexity with each varying angle of skew). ?

3. Progressively closing joint openings. sealer can not cure this

4. Progressively opening joints.

5. Progressively decreasing stroke of joint movement.

6. Progressively increasing stroke of joint movement.

7. Vibratory movement from heavy traffic loadings, military vehicles such as tanks, snowplow impact, etc. Is it of magnitude?

8. Positive or negative creep.

   a. Visco elastic flow.

   b. Drying shrinkage.

   c. Grower aggregates. → can not cure this

9. Warping of slab ends from temperature differentials within slabs or structural members, orthotropic surface plates and subframing, etc. again sealer cannot cure this.

10. Slab end rotation:

   a. Temporary rotation such as from heavy traffic loading at midspan.

   b. Permanent rotation from progressive increase in dead load deflection.

11. Unloading of movement from one end of a deck slab to the other due to mechanical restraints such as frozen bearings, excessive friction, etc.

12. Dual movements of different categories resulting from changes in direction in the line of a joint or from vertical to horizontal or a combination of both. (Skew joints changing direction at the curb).

While it is possible to apt most of these movements only complex structures will have many of sufficient magnitude to be concerned. The sealer is not the cure-all element.

13. Cross joints and variations of "T" junctures with their peculiar movements and stresses.

14. Vertical deflection movements at joint interfaces from loading cantilevered slab ends.

15. Articulating movement.

16. For longitudinal joints between adjacent structures, differential racking movement should be anticipated. In addition, differential vibration when one span is being loaded with traffic while the other is not, should be taken into account. (See Figure 41).

17. Zero movement phenomenon. Evidence exists which suggests that certain compounds of elastomers and polysulfides can be relatively short lived if there is little or no movement involved in the exposure.

While the above list covers many of the major sources and categories of movement found on bridges and structures, it is not construed to be all inclusive. Environmental conditions in specific bridge locations should be thoroughly evaluated to search out all of the factors that could produce erratic movement such as wind, sun, chill, etc.

Whether the movement at the joints is one inch such as the case might be in a simple 80 foot long span, 14 inches for each joint which is the case on the new Severn Bridge in England for a temperature gap of only 60 degrees, 22 inches anticipated on the Port Mann Orthotropic Bridge in Vancouver, B.C. or 72 inches which was predicted for the new Forth Bridge in Scotland, the movement must be accounted for in the design of the jointing and sealing system with an additional provision for some margin of safety.

PRESENT PRACTICE IN UNITED STATES FOR LONGER SPANS

Monolithic tubular, compartmented, compression seals are being widely used on bridges and structures for small movements of 1/2" up to and including 3". (See Figures 42-47). Movements in excess of this would call for different practice. For most long span bridge movement in excess of 3 inches, slider plate and finger joints are being used with no attempt to seal these joints being made whatsoever. (See Figures 48-51).

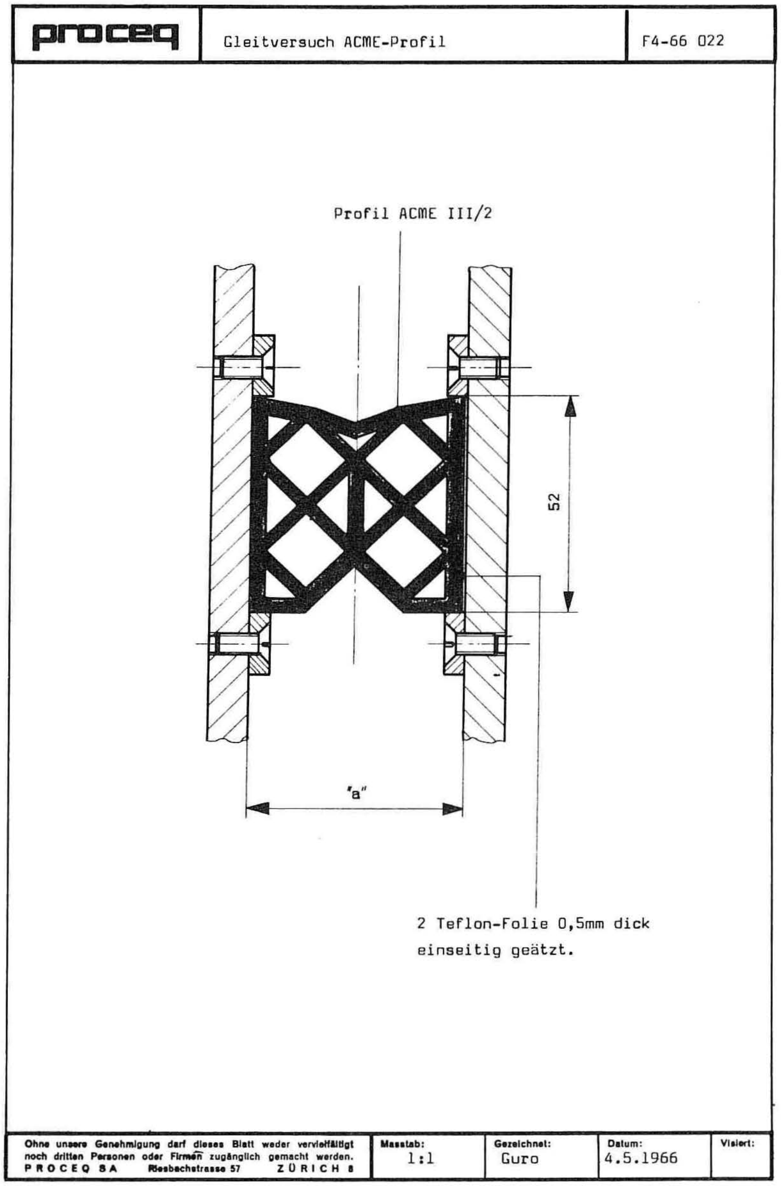

Figure 41. Swiss-German compression seal utilizing 5 mm of Teflon bonded to the elastomer and 5 mm of Teflon bonded to the steel interface of a longitudinal joint. Stops are affixed to top and bottom to resist floating or migration. Used to accommodate distance change between interfaces, differential longitudinal movement and severe vibration from traffic loading on longer spans.

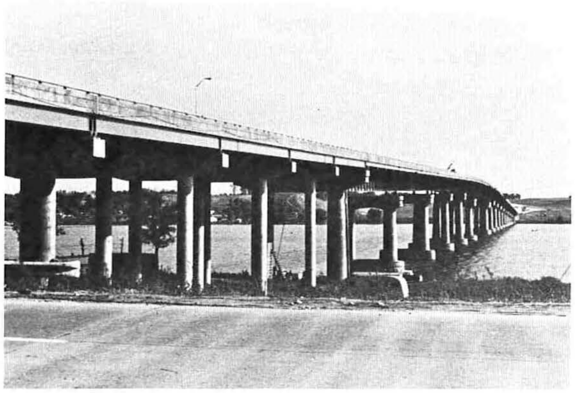

Figure 42. Leclair Bridge on Interstate 80 over Mississippi River utilized 3" wide compression seals throughout.

Figure 43. Leclair Bridge. Lubricating the joints and inserting the seals with a "pogo stick" inserter.

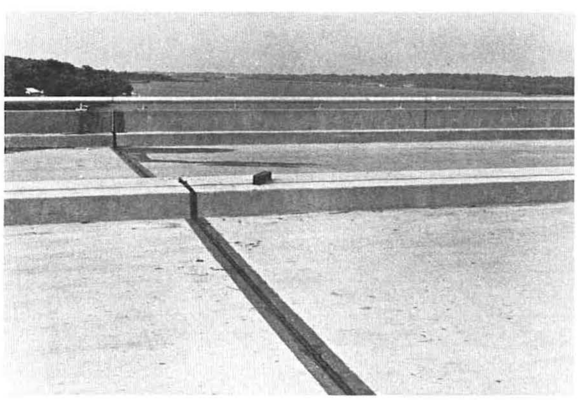

Figure 44. Leclair Bridge. Seal is inserted in a single length free of breaks from outside balustrade through the deck, mall curb and to the other side.

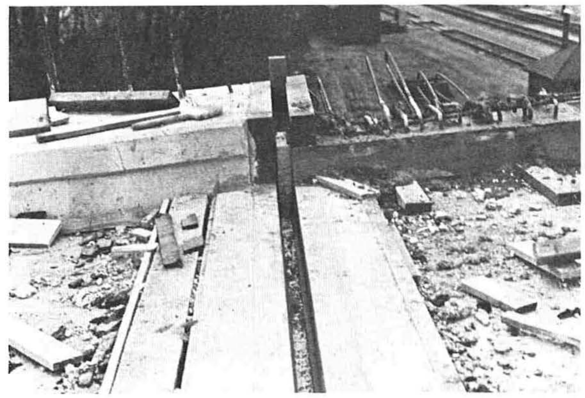

Figure 45. A continuous span in Manitoba. Armor plated joints with seal seats provided.

Figure 46. Continuous span in Manitoba. Winding a 4" seal through the curbline.

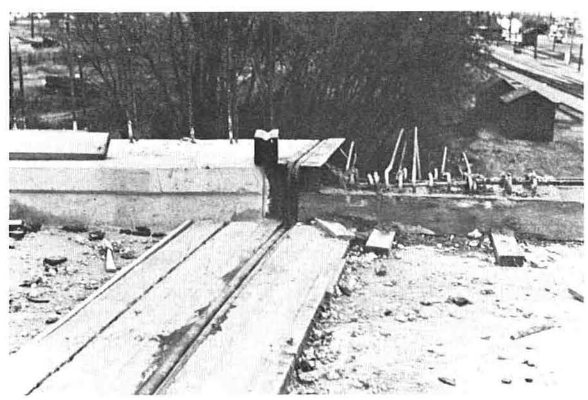

Figure 47. Continuous span in Manitoba. Slightly less than 2" of movement is anticipated at each joint.

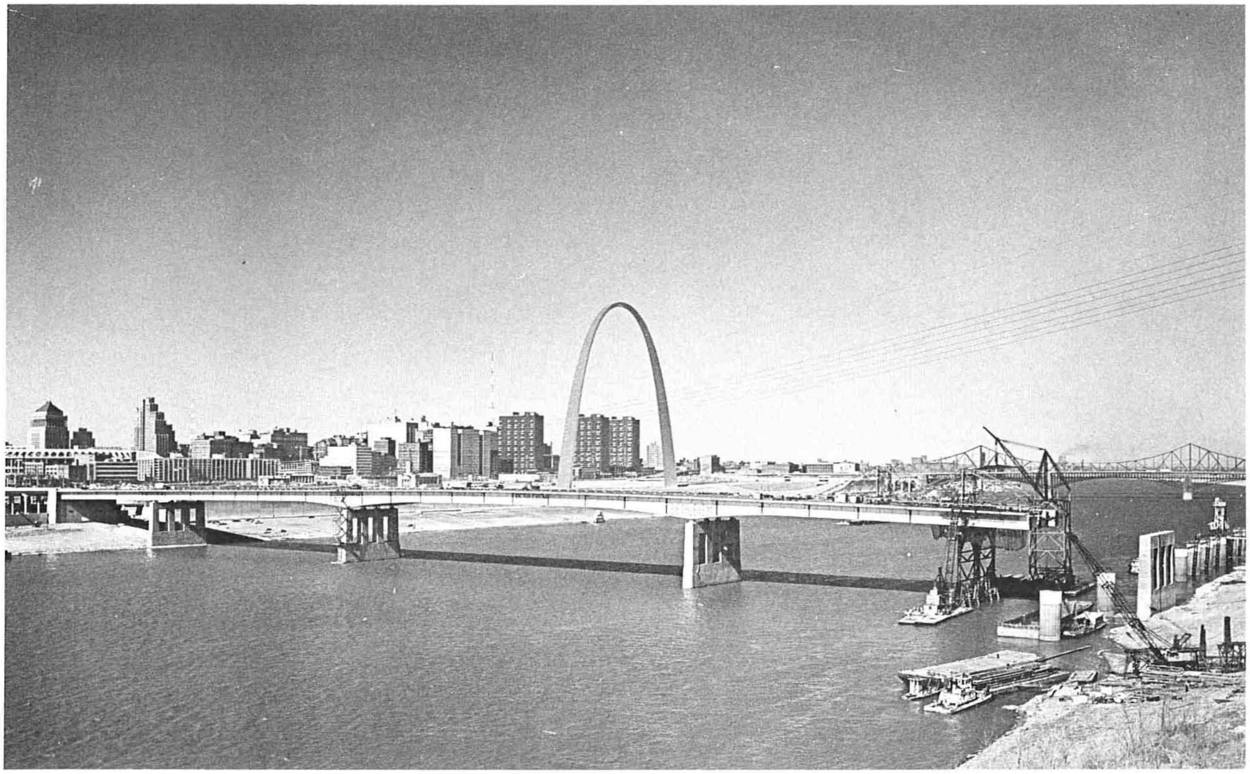

Figure 48. Poplar St. Bridge at St. Louis, Mo. (Orthotropic)
Also known as Bernard F. Dickman Gateway Bridge.
Weight of steel on main span - 13,000 tons.
Approximate cost of main span - 8 million dollars.
Weight of one finger joint - 40 tons.
Approximate cost of finger joint - $25,000.
Movement at East Joint - 11 inches (1365 ft).
Movement at West Joint - 8 inches (800 ft).

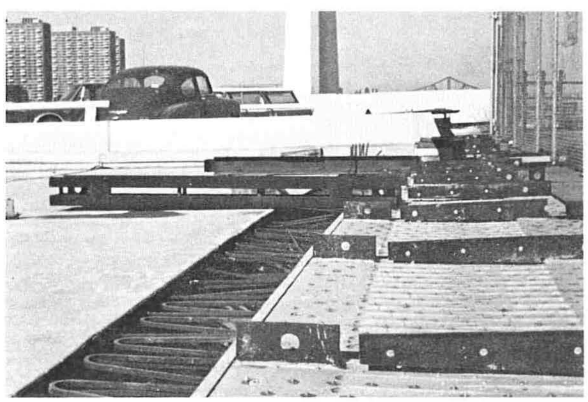

Figure 49. Poplar St. Bridge at St. Louis, Mo. (under construction).
Finger joint at West abutment to handle 8" of movement.
Weight of finger joint approximately 40 tons.
Approximate cost - $250 per foot. (100 ft. wide).
No attempt is made to seal joint.

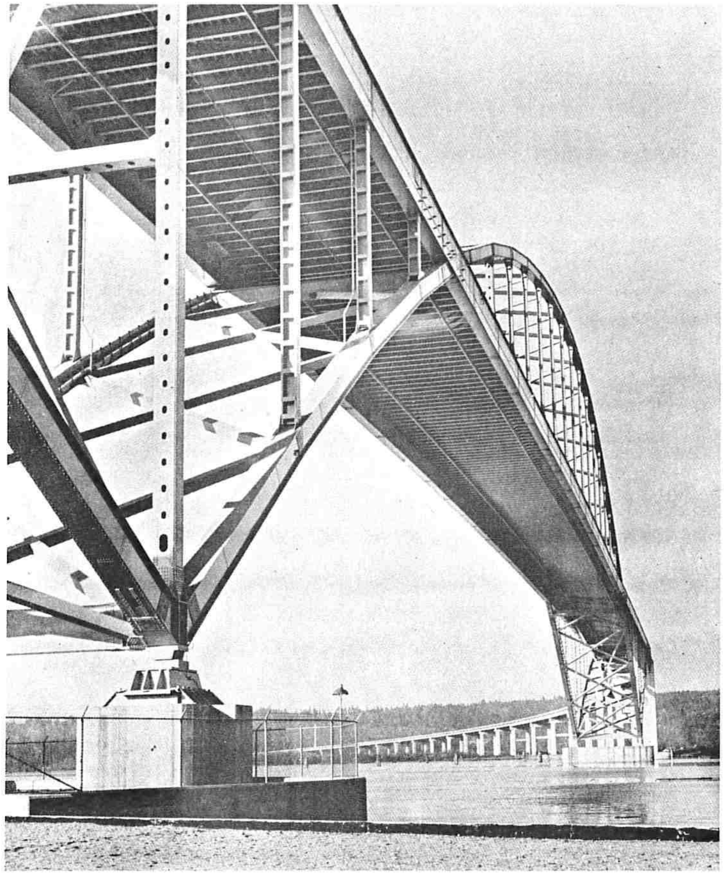

Figure 50. Port Mann Bridge (Orthotropic) Vancouver, BC.
Weight of main and approach spans - 19,660 tons.
Length of continuous portion - 1920 ft.
Weight of expansion joint - 50 tons.
Approximate cost of expansion joint - $37,000.

Figure 51. Sliding plate joint on Port Mann Bridge of rolling link or chain type.
Anticipated movement - 22 inches.
Approximate cost - $700 per foot for a width of 54 feet.
No attempt is made to seal the joint.

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FREE WORLD JOINT SEALING PRACTICES FOR LONG SPANS

Obviously there are no fundamental differences in the sealing problem on bridges here or abroad assuming that the performance conditions are similar, however, in many of these countries abroad, there are differences in general construction practices and policies that appear to effect the design or selection of a joint sealing system.

Construction is often accomplished by means of engineer-contractor type firms. A greater latitude in selection of the sealing system is enjoyed by the contractor who builds the bridge, however the legal responsibility for maintenance of the joints is also mandatory. In many countries, the maintenance of joints is the contractors responsibility for as much as ten years.

European bridge designers have gone almost exclusively to continuous spans. The inevitable result is that they are left with only two joints - or on very long bridges - only a few joints, and so the sealing problem is magnified and must be dealt with in all of its accumulated magnitude.

There seems to be a generally accepted rule abroad that the individual joint openings regardless of how much movement is involved, must never exceed 50 mm (2 inches) at the widest time of opening. This in all likelihood is due to the relatively high percentage of bicycle traffic and greater amounts of small wheel diameter compact cars.

Permissable axle loadings seem to be somewhat higher and the tire diameters appear to be comparatively smaller than North American truck traffic. The dynamic effect of wheel impact upon joint edges is significantly greater and this is reflected by the rugged nature and thickness of steel cross sections on their armor plated joint interface designs. This thickness is also justified by bridge designers in being necessary to absorb vibrations and has a definite damping effect. Where bolts are used to hold sealing devices in place, the French place 7 tons of prestress per foot of joint while the British suggest that not less than 12 tons per foot be applied. If armor plates are being held by supporting bars or lugs, they should be welded to the main reinforcement of the bridge and treated as a cantilever with no credit being taken for lug imbedment.

It is an extreme rarity in Europe to see any serious attempt at sealing bridge joints without incorporating some rugged type of armor plating of the joint interfaces. As the photographs indicate, the husky nature of these armor plating systems may give rise to question, but European designers attest to their absolute necessity for any permanency of joint sealing. It is the feeling that they can only seal with permanency where the interfaces have a long life expectancy.

It is the practice abroad to rate a sealing system's performance capability in terms of millimeters of movement while the American practice has been to talk in terms of % of joint opening. It is suggested that the European system may be a more realistic one.

European designers think in terms of much greater design life than do Americans. German bridge designers have advised that they have an overall ultimate design life thinking in terms of 80 years of service. Obviously many of the organic materials used in joint seals would be woefully inadequate in this respect but this is recognized and when a sealing material or device is being considered by an engineer-contractor firm, its actual true performance life is taken into consideration.

The initial cost of joint sealing systems used in Europe today appears to be significantly greater than their counterpart systems in North America. It may well be however, that the cost over a ten year period of service is in all likelihood significantly cheaper. The European thinking is to build sophisticated, low maintenance, sealing systems of a predictable life initially, and so stretch out the maintenance free life of the structure. (See Figures 52 & 53).

TYPICAL AMERICAN SEALING PRACTICE FOR LONGER SPANS

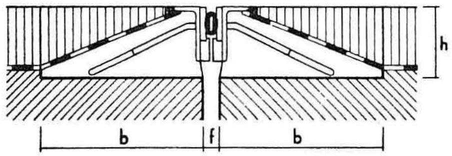
In light of the previously established performance criteria for a joint sealing system on longer span bridges, some typical sealing solutions are shown in Figures 54-56.

Figure 54 illustrates a system which is now in widespread use throughout much of the United States, Canada and a number of countries in the free world.

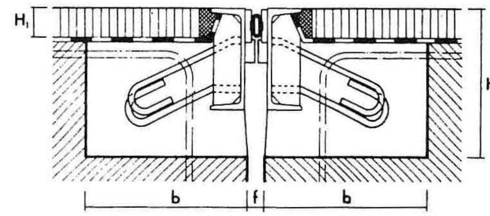
Figure 55 establishes a modular system by incorporating a series of standard seal configurations, each with a known movement capability. The appropriate number of seal cross sections are selected and separated by counter supported vertical steel plates to meet a performance need of 5", or whatever might be the requirement.

Figure 56 is a facsimile of a sealing system presently being utilized on a long span bridge in Canada with a movement prediction of 18" at each joint. While there would be no theoretical limit to the amount of movement that could be built into sealing system, the above bridge sealing system is apparently the most versatile to date, utilizing the principle of compression.

FOOTPATH



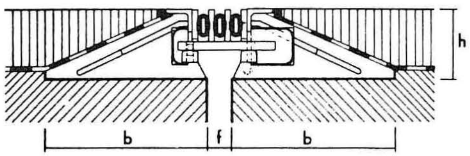
ROADWAY



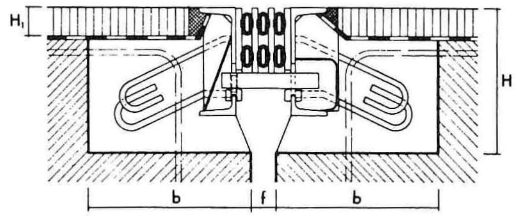
expansion in mms	number of pads	f = central position at 10° C	ROADWAY		FOOTPATH	
			desig-nation of types	weight * kg / m	desig-nation of types	weight * kg / m
1 – 20	1	40	F 20	105	G 20	66
21 – 40	2 x 2	50	F 40	168	G 40	92
41 – 60	3 x 2	60	F 60	190	G 60	105
61 – 80	4 x 2	70	F 80	240	G 80	112
81 – 100	5 x 2	100	F 100	277	G 100	130
101 – 120	6 x 2	120	F 120	303	G 120	142

DIMENSIONS RECOMMENDED FOR RECESSES
b = 400 mm, h = 170 mm, H = 350 mm, H_1 = 50–80 mm

FOOTPATH



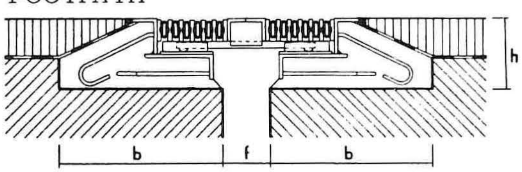
ROADWAY



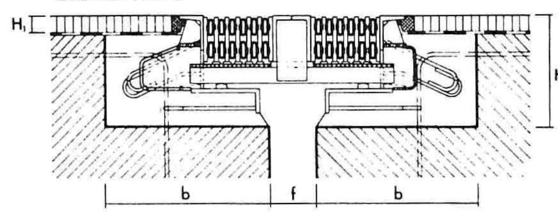
expansion in mms	number of pads	f = central position at 10° C	ROADWAY		FOOTPATH	
			desig-nation of types	weight * kg / m	desig-nation of types	weight * kg / m
121 – 160	8 x 2	120	F 160	494	G 160	290
161 – 200	10 x 2	150	F 200	584	G 200	360
201 – 240	12 x 2	170	F 240	622	G 240	390

DIMENSIONS RECOMMENDED FOR RECESSES
b = 600 mm, h = 250 mm, H = 400 mm, H_1 = 50–80 mm

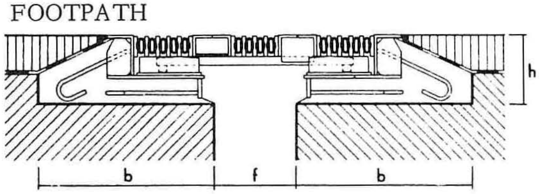
FOOTPATH



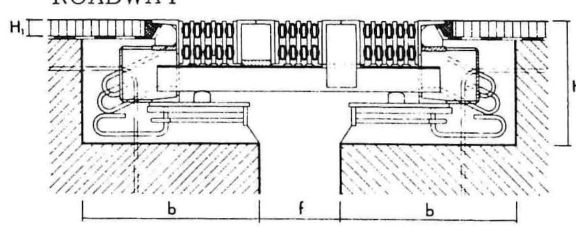
ROADWAY



FOOTPATH



ROADWAY



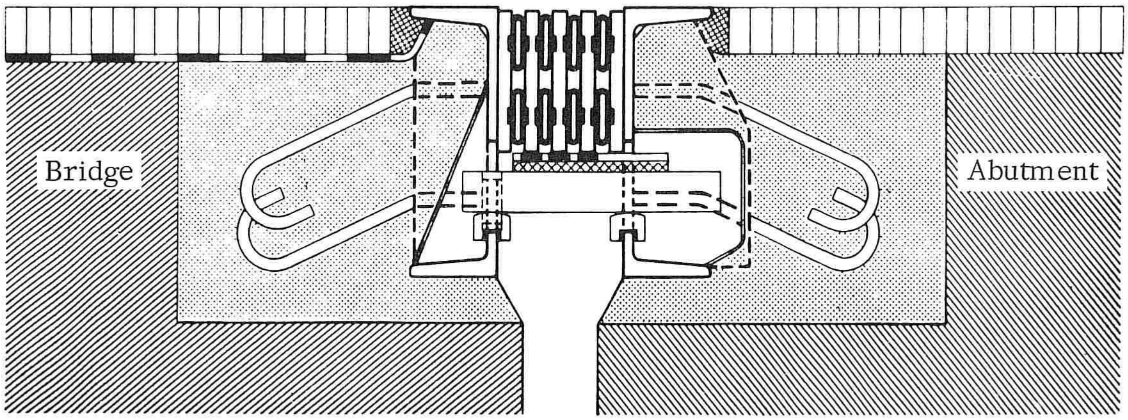
expansion in mms	number of pads	f = central position at 10° C	ROADWAY		FOOTPATH	
			desig-nation of types	weight * kg / m	desig-nation of types	weight * kg / m
241 – 280	14 x 2	300	F 280	970	G 280	465
281 – 300	15 x 2	320	F 300	1020	G 300	490
301 – 320	16 x 2	340	F 320	1055	G 320	505
321 – 340	17 x 2	360	F 340	1090	G 340	525
341 – 360	18 x 2	380	F 360	1130	G 360	545

DIMENSIONS RECOMMENDED FOR RECESSES
b = 750 mm, h = 250 mm, H = 450 mm, H_1 = 50–80 mm

* without neoprene material

Figure 52. Examples of European Sealing System for long spans rated according to movement. (System RUB)

SUMMER



WINTER

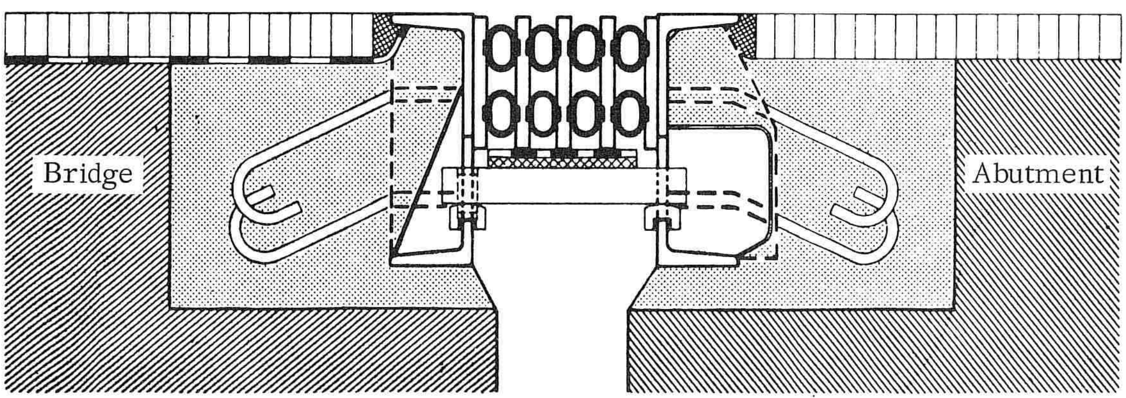


Figure 53. Stages of movement (80 mm).
(System RUB)

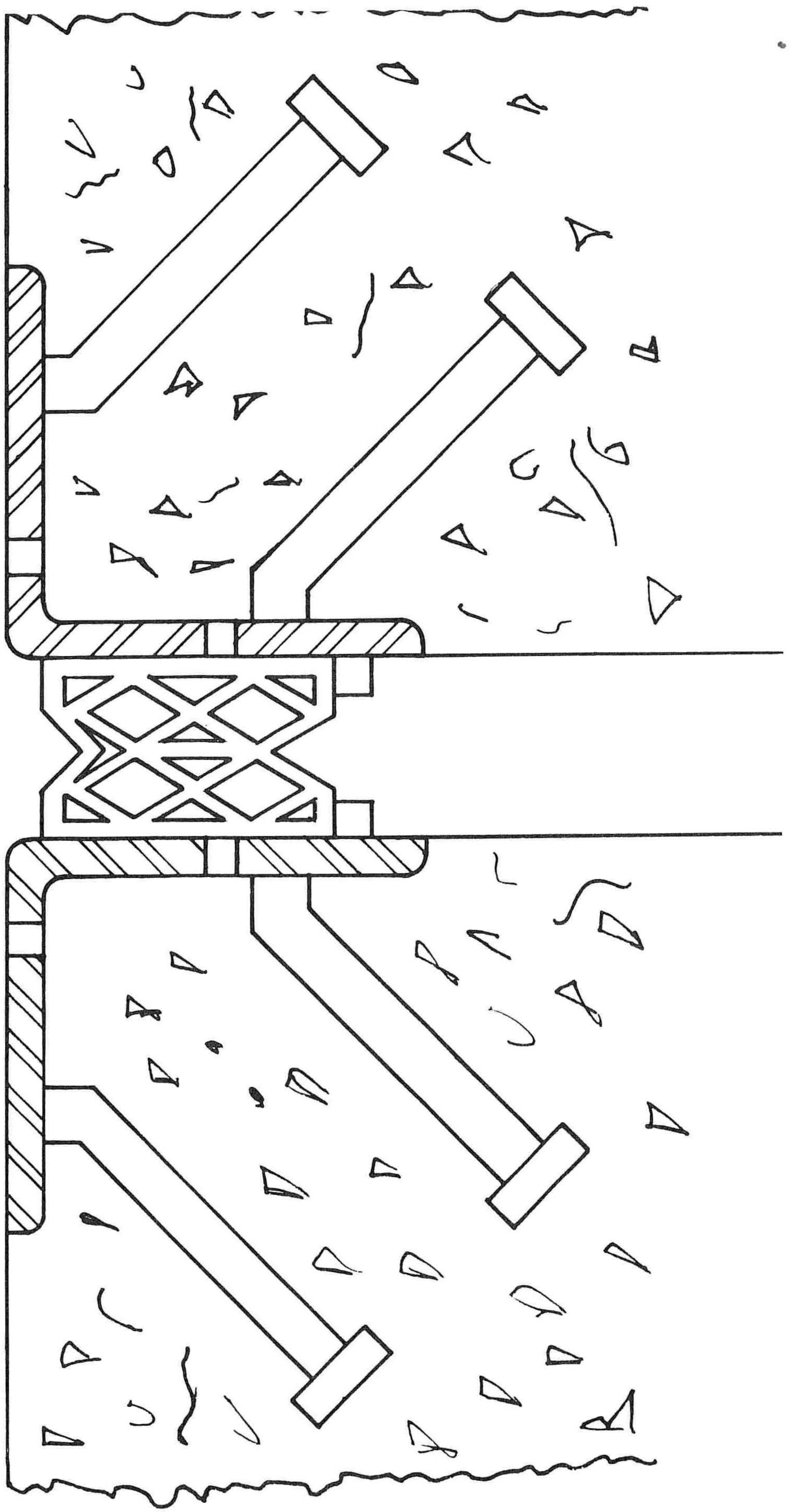


Figure 54. Sealing system for 1-2 inches of movement.

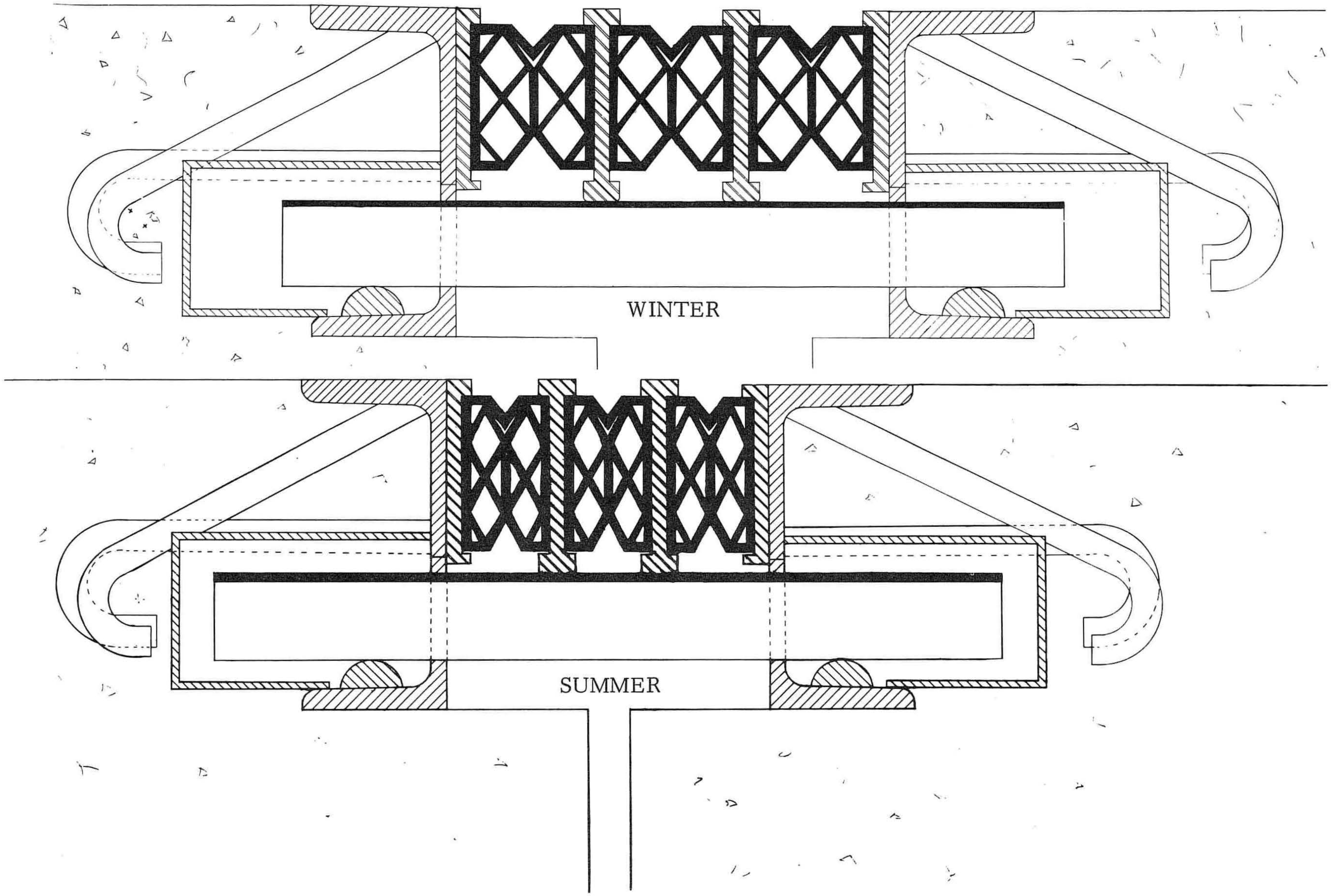


Figure 55. Sealing system for 5 inches of movement.

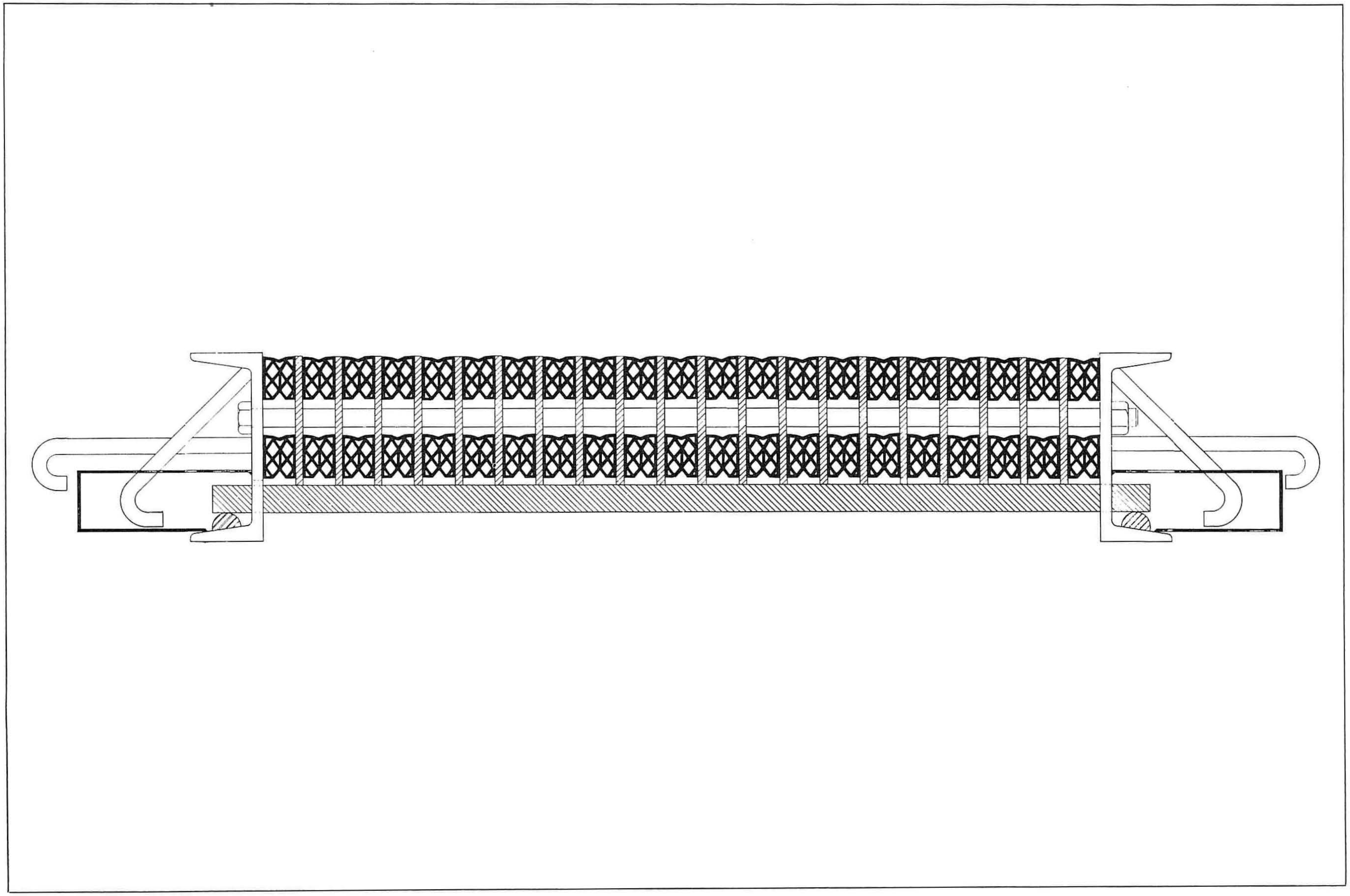


Figure 56. Sealing system for 18 inches of movement.

SUMMARY

1. A foreseeable trend to longer span bridges together with the realization that there is a definite, causal relationship between certain identifiable types of premature bridge distress and ineffective sealing practices has led to the recent development and use of a number of interesting new sealing systems using the compression principle.

2. A recent photographic study of premature bridge distress has been accomplished in an attempt to better understand what is happening and what can be done to eliminate or at least minimize the problem.

3. A performance criteria for a sealing system has been established to assist bridge design engineers in the selection of an effective sealing system from the available candidates.

4. Typical sources and categories of movement phenomena on bridges are described and their importance underscored in long span joint sealing practice.

5. It is the responsibility of the design engineer to identify, describe and predict the magnitude of each of the types of movement that might occur at the joint interfaces on his structure.

6. Examples of current sealing systems and solutions in the United States and Europe are illustrated and discussed in terms of their performance capabilities.